STRENGTH OF CONCRETE USING THE MATURITY METHOD MSP 03-03

1.0 Description. This specification covers the maturity method as a non-destructive means of determining in-place concrete strength for pavement or structural applications. The concept of the maturity method is based on the combined effects of concrete age and temperature, during hydration, on the rate of strength gain for a specific concrete mix. This method requires the establishment of a relationship between compressive strength and calculated maturity indices for a specific concrete mixture prior to placement of the mixture in the field. The contractor may use the maturity method in accordance with this specification to estimate the compressive strength of the in place concrete.

2.0 Procedure. In-place concrete strength determined by the maturity method shall be in accordance with ASTM C 1074, except as noted herein.

2.1 Maturity Meter. The maturity meter shall have a secure means of collecting data that is unalterable.

2.2 Maturity Function Values. In lieu of determining values for datum temperature, T_o, or activation energy divided by the gas constant, Q, values of 14 F (-10 C) or 5000 K may be used, respectively.

2.3 Standardization. Verify the calibration of systems used for monitoring the maturity of concrete every seven working days in accordance with AASHTO TP 52, Section 9.1 and ASTM C1074, Section 7.1.

2.4 Development of the Strength-Maturity Relationship The contractor shall develop the strength-maturity relationship prior to placing any concrete on the project. The contractor shall notify the engineer prior to development of the maturity curve. The development of the strength-maturity relationship shall be done in the field using project equipment and materials.

2.4.1 When the strength-maturity relationship is developed, compressive strength specimens shall be fabricated, cured and tested at the plant site and fabricated from a minimum 3 cubic yard (2.3 m^3) batch of concrete. All field specimens shall be fabricated and cured according to AASHTO T 23, with the following exceptions. Specimens shall be cured for the first 24 hours under similar or like temperature conditions anticipated during construction, and specimens, including the cylinder used to monitor temperature, shall be demolded at approximately 24 hours and cured according to AASHTO T 23, Section 9.1.3. The concrete mixture shall meet the specification requirements in order to determine the strength-maturity relationship. The concrete mixture shall be at or above the target air content established by the contractor.

2.4.2 The contractor shall provide the engineer with the following information prior to placing any concrete on the project:

(a) The project number, route, county, concrete job mix number and date of testing.
(b) The air, slump, and water content from the batch of concrete tested.
(c) The amount and type of admixtures used in the concrete mix.
(d) The strength of each test specimen and the average strength of test specimens at each test age.

(e) Maturity index for each instrumented test specimen and the average maturity index for the instrumented specimens at each test age.
(f) A graph of the average compressive strength versus the average value of the maturity index as described in the strength-maturity relationship section of ASTM C1074.

2.5 Compressive Strength Testing. At a minimum, compressive strength tests shall be performed on three specimens and the average strength computed at 1, 3, 7, 14 and 28 days. Production may start after the seven day compressive strengths have been determined.

2.6 Placement of Temperature Sensors. For pavement and pavement repairs, temperature sensors shall be embedded at approximately mid-depth and 18 inches (450 mm) from the edge of pavement. For other applications, temperature sensors shall be embedded in locations that are considered critical in terms of exposure conditions and structural requirements. Temperature sensors shall be placed at the following frequency:

Structure Component	**Frequency**
Pavement	1 sensor per 3600 sq. yd. (3000 m^2), with a minimum of one in the last 50 feet (15 m) of pavement.
Pavement Repairs	1 sensor per 10 patches, with a minimum of one sensor in the last patch.
Structural	A minimum of one sensor at the end of the pour, with three other sensors available to be placed as directed by the engineer.

3.0 Proportioning, Mixing, Placing and Curing Field Placed Concrete. The maturity method does not account for variations in strength due to proportioning, mixing, placing and curing of concrete. Proper methods shall be followed at all times during proportioning, mixing, placing and curing the field placed concrete.

3.1 Field Placed Concrete Mix Requirements. Mix constituents of the field placed concrete shall not change, and mix proportions of the field placed concrete shall not vary more than five percent from the concrete mix used to develop the strength-maturity relationship. The water cement ratio shall not vary more than 0.02.

3.2 Requiring Immediate Validation of Strength-Maturity Relationship. If the mix constituents change more than five percent, the water cement ratio changes more than 0.02, the material sources change or the mixing operation changes, an immediate validation of the strength-maturity curve shall be done according to Section 4.0.

4.0 Validation of Strength-Maturity Relationship. At minimum, every seventh day of concrete placement a validation test shall be conducted to verify that in-place concrete strength is accurately represented by the strength-maturity relationship. The engineer shall be notified when and where the validation test will be done.

4.1 The validation test shall be as follows.

4.1.1 The contractor shall document the air, slump, and water content from the batch of concrete tested and any deviations from the original job mix.

4.1.2 During placement of the field placed concrete, a minimum of four compressive strength cylinders shall be fabricated and cured as specified in section 2.4.1 of this provision.

4.1.3 Embed a temperature sensor to within ½" (+ or -15 mm) of the center of one cylinder for computing the maturity index from the measured temperature history as specified in section 2.0 of this provision.

4.1.4 Once the maturity index, according to the temperature monitored cylinder, is achieved which corresponds to the maturity index desired for the first critical action (such as opening pavement to traffic or removing formwork), test three cylinders for compressive strength.

4.1.5 Compare the average compressive strength of the three cylinders to the compressive strength as determined by the strength-maturity relationship. If the predicted strength is within 10 percent or 200 psi; whichever is less, of the actual compressive strength, then the strength-maturity relationship is considered validated.

4.1.6 If the actual compressive strength is more than 10 percent or 200 psi (1380 kPa), whichever is less, below the compressive strength as determined by the strength-maturity relationship, then a new strength-maturity relationship shall be developed.

4.1.7 If the actual compressive strength is more than 10 percent or 200 psi (1380 kPa) above the compressive strength as determined by the strength-maturity relationship, then a new strength-maturity relationship may be developed.

4.2 If the actual compressive strength is more than 10 percent or 200 psi (1380 kPa), whichever is less, below the compressive strength as determined by the strength-maturity relationship, the contractor shall make cylinders to determine compressive strengths until anew curve has been developed.

5.0 Field Documentation. The contractor shall provide the engineer with the following information prior to taking any field action based on the strength-maturity strengths:

(a) Project number, route, county, and date tested.
(b) A list for each concrete lot evaluated.
(c) Station numbers.
(d) Quantity of concrete.
(e) Maturity index determined for each sensor location.
(f) Estimated strength determined for each sensor location.

5.1 The contractor shall record all test results for equipment calibration and verification. The contractor shall maintain all results in an organized format and available to the engineer at all times.

6.0 Basis of Payment. No additional payment will be made for compliance with this special provision.